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THE PERCEPTION OF MOTION

THE recent papers of Messrs. Hollingworth[1] and Pitkin[2] upon what the former calls "The Law of the Resting Point" suggest that some analogous observations of my own may be of general interest. I will venture to leave my statement in the form in which it was written before Dr. Hollingworth's article appeared.

I

The key to our conception not only of the continuity, but also of the reality of nature is our perception of change. Hobbes's dictum, "Always to perceive the same thing is equivalent to perceiving nothing at all," is the assertion of what all experience seems to substantiate, *viz.*, that our perceptions gain their reality from their variety; and variety can be defined only in terms of change, or of passage from one thing to another. On the other hand, if the change or transition were absolute, if our perceptions were merely of isolated and unrelated things, we should again have no variety and no reality; Hobbes's dictum would apply to each thing in separation, and instead of a sum we would have only a set of meaningless ciphers: we might paraphrase Hobbes, "Never to perceive the same thing is equivalent to perceiving nothing at all." Perception of reality is contingent upon perception of sameness coupled with difference, unity with variety; and neither of these can be clearly conceived apart from the other.

The relation of sameness to difference, unity to variety, the one to the many, we represent to ourselves by means of the notions of change and motion. For example, we define any given line $m — n$ as the path of a moving point, passing from m to n; m and n represent the elements of difference in the total conception, the path, p, the uniting sameness; no element in the group is significant apart from the others. All our notions of motion, and hence all our notions of space (which is a construct of lines), are built upon this idea. The case of non-spatial change is analogous. The succession of two experiences in time we conceive as a kind of addition, $\alpha + \beta$, in which the $+$ is a sort of tie at once joining and holding apart the qualities α, β, distinguished as *before* and *after*. Indeed, time in general is commonly symbolized by lines (time-curves, and the like) showing the fundamental identity of spatial and temporal continuities.[3] Purely ideal changes follow the same plan, as may be clearly seen in the syllogistic inference: *A is B, B is C, therefore, A is C; A* and *C* represent the differences united by the middle term *B*, which is the tie that justifies the passage from *A* to *C*, and which must be felt, even if it be not expressed, in the conclusion. A beginning, a middle, and an end, are alike present in our spatial, temporal, and logical perceptions; and in this general form of perception, the middle is the fluid or moving connection which tells us that *this* solid beginning has passed into just *this* solid end. "Everything that changes," saith Philosophus, "is something and is changed by something and into something"; and if we make that by which a thing is changed an inherent force (as ultimately we do), this saying will serve as a pattern for all our perception of reality.

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[1] "A New Experiment in the Psychology of Perception," this JOURNAL, Vol. X., page 505.

[2] "The Law of the Resting Point," this JOURNAL, Vol. X., page 657.

The Greeks accepted as an axiom of physics that "some things are in motion and some at rest." This but states formally what our sense experiences continually assert. We see moving objects, but we see them as moving only because they traverse a stationary background, or because we ourselves are in motion, in body, in head, or in the eye muscles. From vision alone, unaccompanied by kinesthetic sensations, it is frequently impossible to tell whether it is the perceived objects or our own bodies which move. A familiar illustration of this is the experience of uncertainty which comes when one is seated in a railway car beside another train, as to whether it is one's own or the parallel train that is starting; the visual sensation of motion so strongly suggests the accompanying kinesthesis that it is only by comparing the observed train with some object known to be stationary that we can assure ourselves that we are not in motion. Similarly, if a train passes at express speed your own more slowly moving car, it gives you not only the visible, but also the bodily feeling of slowing down; you are able properly to judge your own speed by observation of telegraph poles or other stationary objects—which themselves have the illusion of motion. Thus it is evident that perception of motion is normally visual-kinesthetic; and in ordinary experience it is the kinesthetic element which tells us whether our bodies or the perceived objects are in motion; in other words, kinesthesis gives us perception of bodies in motion, vision of bodies at rest; or, in any given motion $m — n$, vision defines for us the limiting stations, m, n, kinesthesis supplies the connective p.

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[3] Kurt Bernhard, in an article on "Die Relativität der Zeit" (*Archiv. für Systematische Philosophie*, XIII., 3), gives space a kind of conceptual priority to time for the interesting reason that "time is a straight line," *i. e.*, we fall back upon spatial representations when we wish to express temporal relations, but feel no corresponding necessity in regard to space, which (as geometry shows) is describable in terms of its own characteristics. The "*Zeitlinie*" is not a circle nor a closed curve, nor a type of curve leading into infinity; it has no single points, and it is continuous; the straight line, one dimension, is its proper image. This view is interesting in connection with Minkowski's suggestion ("Raum und Zeit," *Jahresbericht der Deutscher Mathematiker Vereinigung*, Vol. XVIII.) that time may be treated, mathematically, as a fourth dimension. . . . The problem involved seems to be one of the symbolization rather than of the intuition of these "forms of experience."

This must not be taken to mean that the sense of sight can not by itself give perception of motion. Most of our perceptions of motion are purely of this sense. Particles too small for detection while at rest become visible so soon as they are in motion; even so large an insect as the house fly is often difficult to discern if it remain stationary. Perhaps the most astonishing illustration of this power is the fact that the illuminated paths of ions—the infinitesimal particles of the infinitesimal atoms that compose the invisibly minute molecules—have been shown to be visible. And in the biological realm the fact that the very young of many animals escape observation by lying unmoving, while most animals may be startled into motionlessness, illustrates the relative imperceptibility of stationary objects. Furthermore, there is an obvious difference between visual perceptions of motion dependent upon a general kinesthesis and purely visual motion. In the former case, the movements observed are indistinct and blurred as compared with the minute discriminations of which pure vision is capable. Rapid motion of the body or the head or the eyeballs results in an impression of confused rather than of clear-cut change; it is only when the eyes are definitely focused upon an object that minute changes can be observed,—a glance at a sunny meadow shows it all green, while to our steady gaze it resolves into a play of colors. Perhaps we can generalize with the statement that bodily movement (kinesthesis) tends to resolve motions into *continuities,* static vision into discrete *elements.*

For it is not at all certain that our perceptions of motion, even in vision, are not ultimately kinesthetic. The structure of the eye is such that delicate accommodations are constantly taking place, and these are accentuated the moment the gaze is directed to follow a moving object. Further, the more rapid motions are not seen as motions, but as things. In the case of the ions, above mentioned, what is actually seen is an illuminated *path,* a streak or line, not at all a motion; it is like the wake of a meteor or a flash of lightning which visually assumes an extended form because the motion is too swift for the eye to follow. This appears to be the case throughout nature; we see things as stationary when their motion is too rapid for the eye to follow; all vision is mediated by radiant energy, which represents the most rapid motion known to us, though it is never seen as motion, but only as color or light; so that we might say in general that a motion becomes visibly such in proportion to its slowness, or, at any rate, in proportion to its susceptibility to visual-kinesthetic analysis. A common illustration of the tendency of rapid motion to lose its character as motion is the case of the spokes of a rapidly revolving wheel, which with sufficient speed resolves into a disc of color, or into bands varying in hue with the distance from the hub. We might well liken the bands of the solar spectrum to a similar modification of the etheric vibrations whose different rates correspond to the several colors. Thus again we see actual movement perceived as visible magnitude—as thing or element rather than as transition.

It might be assumed that hearing and smell and the other senses exemplify a similar condition, that what appear to them as qualities are in fact but motions too rapid to be followed in their proper character, and hence are converted into states viewed as if constant. This would square admirably with the physical conception of the objective world as composed entirely of forces, or active energies. It is susceptible also of an obvious biological explanation. Motions which we are to perceive as motions would naturally be such as our bodies could accommodate themselves to; that is, our perception of motion as such is directly proportional to our powers of physical reaction. There is no biological reason why we should see as motion the infinitely swift movement of the lightning, for the reason that we could not dodge it could we see it coming; on the other hand, there is every reason why we should be able to follow the swiftest motions of other animals,—and in general it seems to be that our powers of analytic vision of motion are limited by the range of animal locomotion, the whirring wings of the humming bird and dragon-fly just passing our powers at one extreme, the vermicular slowness of the snail at the other; we can not quite see the mushroom grow, we can not quite see the lightning speed, but we do not *need* to see either. And in the case of sound, our analytic perception is again roughly bounded by the range of notes open to animal production, the almost inaudibly shrill pitch of some insects at one end of the gamut, the bass growling of the huger mammals at the other; outside of these there is mainly confusion and noise.

II

The actual relation of vision to the perception of motion is beautifully illustrated by certain artistic conventions. The swift motion of a quadruped running has been represented from ancient to modern times by picturing the limbs as extended, parallel before and behind, at their greatest reach (Figs. 1, 2). Instantaneous photography shows that at no time are all the four limbs raised in this manner; the position is a false one. As emphasizing the falsity and conventionality of civilized art in contrast to the superb naturalism of paleolithic European drawing, an interesting comparison has been made between these representations of running horses and the galloping or ambling deer drawn on an ancient bit of horn (Fig. 3); the attitude caught by the primitive artist is just one assumed by the galloping horse, as shown by instantaneous photographs (Fig. 4) and never reproduced in civilized art until so shown.[4] This is no doubt an interesting commentary upon the realistic truthfulness of paleolithic perceptions; but a moment's regard of the pictures will show that the artistic truthfulness of representation is all with the

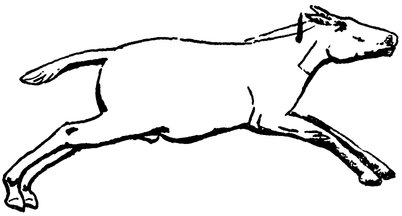

FIG. 1. Running wild ass; low relief, Nineveh.

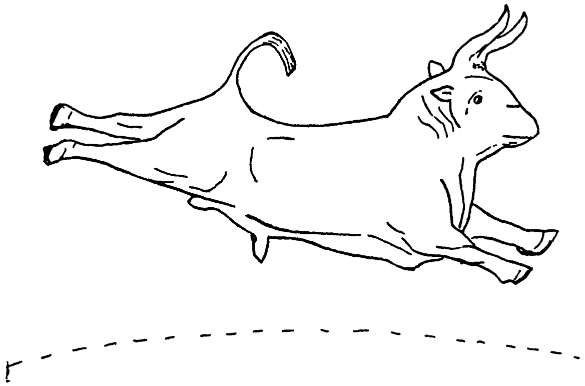

FIG. 2. Running bull; gold cup, Vaphio.

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[4] S. Reinach, "Apollo," Paris, 1904, pages 6–7.

civilized picturing,—the image of a horse running at top speed is properly suggested by the false drawing.

What is the reason for this? Clearly it is an idiosyncrasy of our vision of motion, and this may be stated: the movements of rapidly moving objects are visually indicated by their points of comparative rest, which are also their points of maximum acceleration. This may be graphically indicated by the image of a pendulum (Fig. 5); at the extremity of its swing (*a*) it is in momentary pause, but just this position suggests rapid motion far more effectually than any intermediate position (*b*), while at the point of swiftest motion (*c*) it appears to be stationary.[5] The limbs of the running quadruped are similarly seen at their highest swing, a point of momentary slackening and pause preparatory to regression. Of course this is actually the point of the greatest rate of change of motion, and it may indicate the maximum strain upon visual accommodation.

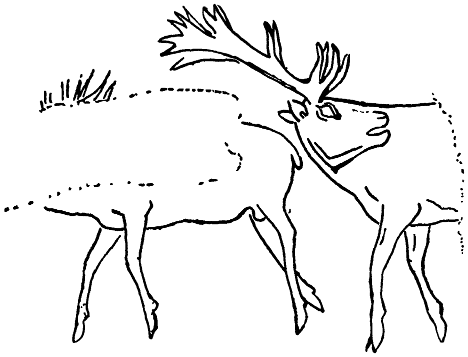

FIG. 3. Galloping reindeer; incised bone, Caverne de Lorthet.

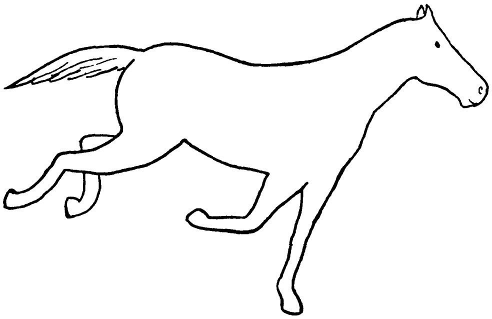

FIG. 4. Galloping horse, after an instantaneous photograph.

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[5] I borrow this illustration from the suggestion of H. G. Spearing, "The Childhood of Art," New York, 1913, page 103.

Another illustration might be drawn from the revolving wheel; motion is actually seen, or best seen, in the twinkling of the spokes nearest the hub, where the movement is really slowest. Again, if you will watch a rapidly receding train or car, instead of a uniform shrinking of the image, it will be seen to diminish in a succession of contractions, the eye interpreting the constant motion as a series of positions or pictures, very similar in effect to the flicker of a cinematographic picture. Thus, again, we find the function of pure vision to be the representation of rests rather than motions, the continuities which it perceives being in space rather than in time, and made up of stations or points rather than of transitions; the transitional element is mainly, if not exclusively, kinesthetic, so that we may reasonably doubt whether the fixed eye of a person congenitally anesthetic to muscle sensations would be able to perceive any motion at all.

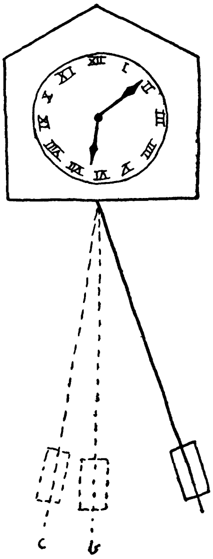

FIG. 5.

An artistic convention of a different type gives us light from a different vantage. This is the tendency to *elongate* the bodies of moving animals. Doubtless the actual extension of the running horse or dog, head low and tail out, or of the flying duck, with neck straight, is greater than that of the same animal in repose; but there is no such elongation of the body itself as appears, for example, in the running bull of the Vaphio cup (Fig. 2) or in the ivory acrobats from Knossos.[6] The instinctive rationality of this convention we must realize when we reflect, for instance, upon the relative ease with which we represent rapid motion in the case of the trout as compared with the bass, or the minnow against the sunfish; chubbiness is all at odds with speed, which pictorially tends to assume the general form of a streak.

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[6] *Cf.* Spearing, "Childhood of Art," Fig. 336*a*.

The instancy with which we transpose motion in time into extension in space—visual movements into visual things—was beautifully illustrated by Professor Cattell's experiments with his wheel chronoscope.[7] "In the ordinary vision of daily life," he writes, "the eyes, the head and the whole body are in continual movement. There are no distinct and lasting images on the retina; the physical conditions are those of the photographic plate when the camera is constantly moved hither and thither. But the world that we see appears to each of us distinct and unshifting. When I glance across the room—along a row of books covering its side, for example—images follow one another in rapid succession, but I see this time continuum as a space continuum with all the objects duly arranged side by side." Professor Cattell's experiment hinges upon a moving stimulus rather than a moving eye (a distinction which is probably of moment, although the results are analogous, as see p. 283 above), but his records very clearly demonstrate the inevitability with which we spatialize our visual perceptions of change. I have observed the same fact in a slightly more complicated form: the after-image of a wheel (in the case noted, a brass electric fan) revolving so rapidly as to appear as a disc, when the eyes were suddenly cast to one side, spread out into an elongated band of color. Here, of course, we have both an obvious retinal and an obvious kinesthetic element, the two uniting to form an exaggerated spatial continuum. The elongation of the body of the Vaphio bull would seem to have a sound psychological *raison d'être.*

And here an adversion to Lessing seems in place—especially since the world of esthetics is just now torn between cubistical artists bent on proving him wrong with the brush and shocked critics manfully maintaining with the pen his invulnerable righteousness. *"Es bleibt dabei: die Zeitfolge ist das Gebiet des Dichters, sowie der Raum das Gebiet des Malers,"* is Lessing's famous dictum.[8] The crust of his discussion is the unpicturableness of motion, the preeminence of repose as the theme of plastic and graphic art. It is first to be noted that Lessing (yielding to an esthetic instinct which was surer than his critical theory) compromises his own generalization. His doctrine of the "fruitful moment," when he comes to apply it to the problem of motion (as distinguished from emotion), induces an immediate modification. "All bodies exist not only in space, but also in time. They endure, and can in each successive moment of their duration appear otherwise and stand in other relations. Each of these momentary appearances and combinations is the effect of a preceding and can be the cause of a following moment, and so can be regarded as the center of an action. Consequently, painting can imitate actions, though only indicatively through bodies."[9] In acceding to Herr Mengs's comment on the treatment of draperies by Raphael, Lessing is again concessive. He quotes Herr Mengs[10] as follows: "Every fold has with him (Raphael) its reason, be it on account of its own importance or from the movement of the limb. Often one may observe from the arrangement of the folds, how they have just been disposed; and Raphael finds significance in this. One sees, in the draperies, whether a leg or an arm, previous to its motion, has been advanced or retracted, whether the limb proceeds from bending to extension, or whether, having been outstretched, it contracts." It is undeniable that the artist, in this case, represents two distinct moments in a single image, says Lessing,—just as the poet, by multiplying his epithets, may outstay his artistic right in some unwontedly charming bit of space. The two arts must be mutually hospitable of such encroachments, like friendly neighbors; but "just as there, with the painter, the two distinguished moments border upon one another so immediately that, without hesitation, they may pass for a single one; so here, with the poet, the several indications of different parts and qualities in space follow one another with such compression and celerity that we believe ourselves to hear them all at once."

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[7] "On Relations of Time and Space in Vision," *Psych. Rev.*, VII., 4, page 325.

[8] "Laokoon," XVIII.

It is evident enough that Lessing was dealing with a bigger problem than the limited psychology of his time could qualify him to handle. In a certain broad way he is probably right as to the essential distinction between poetic and plastic "imitation." Nevertheless, when he comes to the minutiæ of his distinction he fails to give any satisfying account of the painter's significant moment, in so far as it is concerned with the technical portrayal of motion. May it not be that this moment is to be found just at that point in the progress where, perceptually, the movement is crystallized into the visual thing, the action converted into a visible embodiment? The primitive conventions which we have noted seem to imply this.

Of course it would be begging a number of esthetic questions if we were to permit such a satisfaction of Lessing's problems to legalize the "boundaries" which he sets for the arts. Modern painting makes use of spaces undreamt of in his day, and there is no compelling reason why the artist should not experiment with observational moments as well as with angles of regard; it is a mistake to suppose that we are going to stay by the mask of La Mettrie after we have discovered in it the gaping fool, and it may be that we will have caught and passed it in just that instant in which it is triumphantly the laughing philosopher; every one knows that pictures have their moments of glamor, and that it is just for these moments that we love them. Why may not the artist legitimately work for these rapt eternities rather than for the tedious interregna which we fill with conscious criticism? This need not be interpreted that I pretend to understand the cubists!

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[9] *Ib.*, XVI.

[10] *Ib.*, XVIII.

III

It would offend my temperament to leave this subject without suggesting some of its implications. I have touched upon these in the field of esthetics. For psychology they are quite as interesting. Instead of dealing with perception of time and perception of space as if they were as independent as ever Kant thought them, while perception of motion follows as a sort of evolution from their fusion, ought we not to start with perception of motion (or back of that with change) and proceed thence to the explanation of time and space? It is all very well, mechanically, to treat time and space as constants of thought; but mechanics is artifice, and psychically experience seems to follow an inverse mode. The geometers, who develop the idea of space from the idea of motion, seem to have the empirical right of way.

It would be a dereliction to fail to mention Bergson in this context—and supererogation to point the application. But may it not be true that *la durée réelle* esthetizes itself in Lessingian moments? Or again may it indeed be that infinite space and all the extended splendors of the universe are but the contemplated other of the timelessly egoical absolute? For metaphysics, too, our observations seem pertinent.

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SOCIETIES

NEW YORK BRANCH OF THE AMERICAN PSYCHOLOGICAL ASSOCIATION

THE New York Branch of the American Psychological Association met in conjunction with the Section of Anthropology and Psychology of the New York Academy of Sciences, on November 24 and on February 23. The November meeting was held at the psychological laboratories of Columbia University and the February meeting